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A new design for building large, cheap solar water heaters

Kerr MacGregor
MACGREGOR SOLAR
31 Temple Village, Midlothian, Scotland, UK EH23 4SQ
tel: 0044 1875 830 271
email: kerr@macgregorsolar.com
web: www.macgregorsolar.com

ABSTRACT
This paper describes a new design for building large, cheap solar water heaters using a combination of synthetic rubber and metal. The collection efficiency is quite good and the cost is low. A typical system was built for under EU100/m2 in Scotland in 2010.

INTRODUCTION
Solar water heating works but is still too expensive in capital costs. The aim is to prove cost-effectiveness and it is probably much easier to achieve that by reducing cost rather than increasing efficiency. There are many different approaches to reducing costs, including using cheaper materials, increasing the scale of production and also using new designs. This paper describes one such new design which appears to be successful.

DESIGN
Basically the collector is made of a number of layers. Firstly, the foundation or base-board is made of wooden board such as plywood or OSB(oriented strand board). Then a layer of insulation material is laid on top of the base- board. Then a grid of synthetic rubber pipes is laid on top of the insulation. Then a sheet of conductive metal is laid on top of the pipes and screwed to the baseboard with wood screws so that the pipes are squeezed but not shut off. The choice of flexibility in aluminium sheet and pipes and also the spacing between pipes is critical so that the pipes are squeezed tightly against the metal without being shut off.
The metal is given an absorptive surface. Finally a glazing layer is placed above the absorber sheet and fastened securely. A cross-section of a portion of the collector is shown in Fig 1 below.

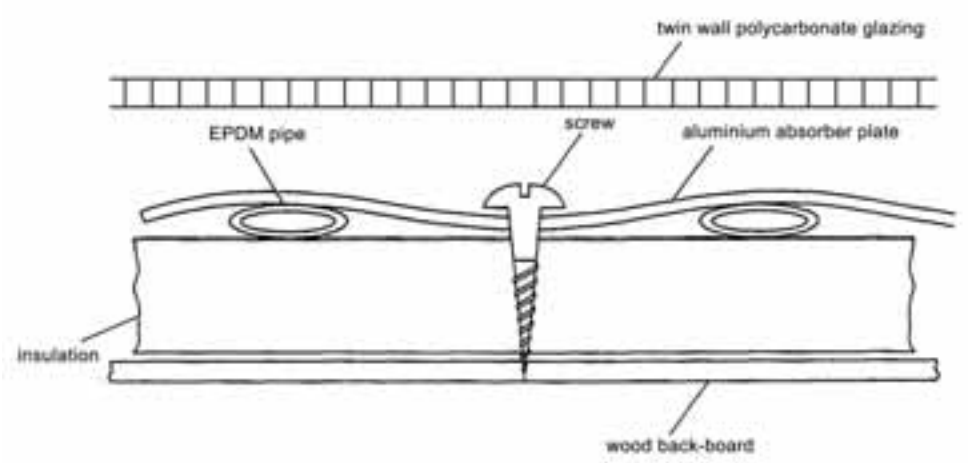

FIG 1.

MATERIALS USED
The backboard was made from OSB board. The insulation was expanded polyurethane foam board.
The pipes were made of EPDM rubber with enhanced thermal conductivity (k=0.8W/mK, 40phr carbon black).
The absorber was made of 0.9mm thick aluminium sheet painted matt black(non-selective). The glazing was of twin wall polycarbonate sheeting.

SYSTEM BUILT IN SCOTLAND
The system was built to operate beside a woodchip boiler to heat a large traditional Scottish castle near Edinburgh.
The collector was built on the ground because the castle is a historic building and a solar collector was not allowed on the roof. The collector was of size 2.4m by 12m long, area (29m2 area) and tilted at 45degrees to the horizontal. It was built by two unskilled men in about 3 days No special difficulties were encountered. The grid of pipes below the absorber were long parallel runs of 16pipes about 160mm apart and connected to large bore manifolds at each end of the collector.
The collector was connected to the heat exchanger in the 1200litre storage tank in an outhouse by insulated plastic pipes buried in trenches in the ground . A pump controlled by a differential temperature switch circulated the water.
Despite the fact that the collector is freeze-tolerant, anti-freeze was used as a precaution.

The only difficulty encountered was due to stagnation in the collector before the water was connected. This caused some of the plastic fittings in the manifold pipes to fail so they were replaced with metal fittings.

Some performance tests were done and collector efficiency in the range 40% to 60% was measured.
A theoretical analysis indicated that the collector had the following characteristic:
Fr.tau. alpha = 0.75 and Fr.U = 5W/m2K.

COST
The overall cost of building the collector, including materials, labour, profit and royalties was about £2,500(EU2,900).

That gives a specific cost of about EU100/m2 which is much lower than most other collectors on the market.

The simple pay-back time replacing commercial fuel at .07EU/kWh and with a collector efficiency of 60% in Scotland, Europe's least sunny country, is about 2.6years which is excellent for solar heat.

DISCUSSION
Several attempts have been made before to use polymer/metal collector designs, notably described by Bartelelsen et al (1). However they used specially formed metal sheets in which the pipes were embedded. This design is simpler and cheaper because it uses plain flat aluminium sheet. The design is the subject of a European patent application (2). It is hoped to further improve and simplify the design further to improve the cost-effectiveness of solar water heating.

It is hoped to build a much larger (500m2) system , unglazed, to heat an open air swimming pool in Northern Scotland.

REFERENCES

1.BartelsenB, Rockendorf G, Vennemann N, Tepe R, Lorenz K Elastomer-Metal Absorber—Development and Application. Proc ISES World Congress, Israel, 1999

2. European Patent Application 05255415.1